

THE DEMAND FORECASTING: A COMPARATIVE REVIEW OF CONVENTIONAL AND NON-CONVENTIONAL TECHNIQUES

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ABSTRACT

Since the inception of competitive markets, demand forecasting has gradually become a fundamental process for all types of the industry's decision making mechanisms. Over the years, the bulk of research was focussed on the identification of pattern in previous demand data of the product. However, with evolving technologies and phase of open markets, demand of any product has witnessed the effect of increasing uncertainty. Academics and practitioners have come to understand that probabilistic and artificial intelligence based non-conventional methods of forecasting are now more important for planning and operations than ever before. With this paper, we offer a comparison of conventional methods and non-conventional models of different forecasting related parameters which helps in understanding the importance of advanced methods in the modern competitive scenario.

KEYWORDS: Demand Forecasting, Time Series & Artificial Intelligence

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INTRODUCTION

This paper provides a comparative review of the literature on various demand forecasting techniques and also identifies various areas where they have been successfully applied. First, we deal with the classification of various techniques so that a better understanding can be made. In the next part, reviews of a number of papers published in last 10 years have been presented which helped in the comparison of different forecasting techniques. Based upon these reviews, Last part deals with a comparison of different demand forecasting techniques is presented on various fronts in the tabulated form.

Demand forecasting is the science of forecasting demand of customer to arrive at a conclusion of such demand by different supply chain and business. It is the prediction of future demand for the given product. In other words, it gives the prediction of future demand on the basis of the past data and current trends in the market. Demand forecasting includes techniques which are both informal methods, and quantitative methods. It is used in various fields of industry, production planning, inventory management, and in assessing future capacity requirements.

Based upon the method of analysis, Demand Forecasting techniques have been classified into conventional and non-conventional techniques as shown in figure 1.

Conventional Techniques are further classified into two categories i. e. survey methods and statistical methods. Survey Methods focuses on the gathering information from various sources and analysing it for

predicting the demand. Various survey methods like Delphi's method have proved their worth by giving good results as they take help of industry experts and personals. Other types of method focus on the previous data and their proper analysis. Commonly adopted statistical methods are moving averages, Trend analysis, regression analysis etc. In the moving average method, year on year demand data is used for calculating next period demand. Trend projection forecasting is one form of quantitative forecasting, which is based upon data from the past. It focuses on numerical data available at various points of time in the past. This available data is usually plotted on a graph in which the horizontal x-axis is used to plot time and y-axis is used to plot the demand. There are several different types of patterns that have been observed to appear on a time-series graph e. g. constant pattern, linear pattern, exponential pattern and other complicated patterns. Barometric technique gives emphasis to indicators from another time series for estimation of a certain series. These indicators can be leading, lagging or coincident indicators. Box-Jenkins tools are basically autoregressive moving average models which aims to provide the relationship between the data.

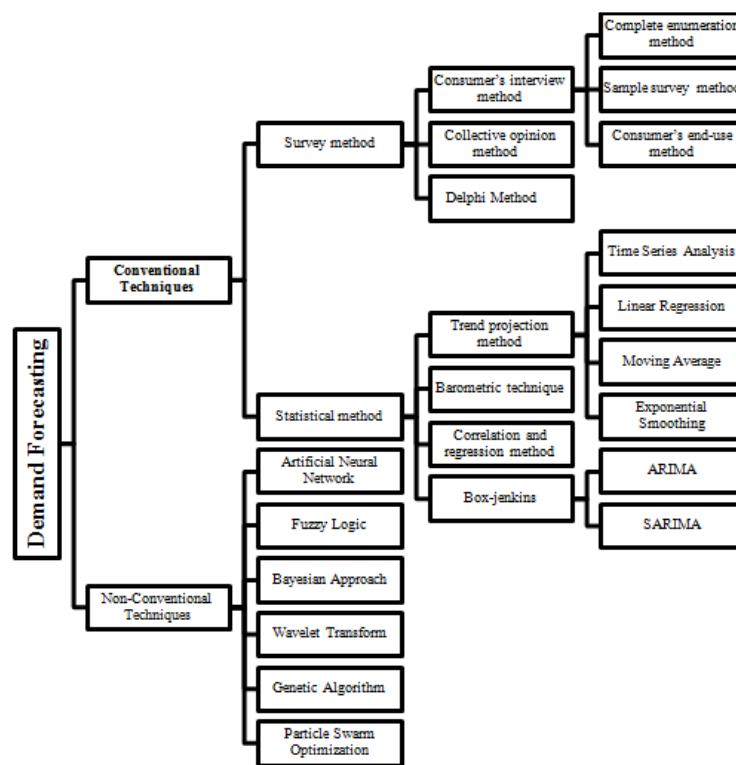


Figure 1: Classification of Techniques of Demand Forecasting

Non-conventional methods of demand forecasting have been continuously evolving over time by making use of different artificial intelligence tools and complex mathematical models including probability theories. Artificial intelligence tools like neural network, genetic algorithm and fuzzy logic have been of great importance in solving problems involving huge volume of data and tracing meaningful patterns in the given data because of their high computational powers. Artificial intelligence tools have an excellent feature of learning from experience, adjusting to new inputs and accomplishing specific tasks without human interruption. Bayesian approach is based upon Baye's probability theory which can help in refining the estimates using a simple process. Wavelet transforms and particle swarm optimization are the other tools which have been widely used in domain of demand forecasting although they are generally clubbed with another technique to get better results.

LITERATURE REVIEW

Demand Forecasting estimates the future demand of a product that is utilized by the organization for its planning. It is generally derived from the forecast of sales and manipulation of demand. This forecast becomes an important component of the decision making of the company. However, it is essential to have in-depth understanding of the different forecasting methods to make a good forecast. Every problem has a specific nature and it must be taken into account while deciding upon the forecasting technique to be employed.

In the past 10 years, a lot of research work has been published demonstrating the capabilities and shortcomings of different demand forecasting techniques. There are conditions where the pattern in the data becomes very complex and demand depends upon a number of factors. A combination of different techniques is generally employed under such conditions giving much more accurate results. Different research works studied for current work have been tabulated below alphabetically.

Table 1: Various Tools used for Demand Forecasting and their Application Areas

Authors	Year	Base Method/Tool used	Application Area	Remarks
Arash Kialashaki, John R. Reisel	Nov-14	Artificial neural Network	Electricity forecast model	Compared various forecasting techniques
Bruno M. Brentan, Edevar Luvizotto Jr. et al	Jan-17	Time series forecasting	Urban water demand forecasting	Hybrid model with Support vector regression
Edward Kozłowski, Beata Kowalska, Dariusz Kowalski, Dariusz Mazurkiewicz	Jan-18	Time series forecasting	Water Demand Forecasting	Harmonic analysis
F. Lolli, R. Gamberinia et al	2017	Artificial neural Network	Intermittent demand of automobile spare parts	single hidden layer network
Federico Poloni, Giacomo Sbrana,	Jun-17	Time series forecasting	Forecasting demand	Multivariate exponential smoothing
Hyojoo Son, Changwan Kim	Aug-17	Particle swarm optimization and fuzzy logic	electricity demand forecasting for Short-term	Use of weather and social variables
Ioannis P. Panapakidis, Athanasios S. Dagoumas	Jan-17	Genetic Algorithm	Natural gas demand	Combination of Wavelet transform, genetic algorithm/ ANFIS
Jennifer J. Bergmana, James S. Noble et al	Oct-17	Bayesian Approach	New equipment demand	Compared with conventional techniques
Jongsu Lee, Youngsang Cho	May-09	Time series forecasting	Passenger car demand	Price and load considerations
José Roberto doRego, Marco Aurélio de Mesquita	Mar-15	Regression Analysis	Automotive spare Parts	Item classification and prediction
K. Nemati	Jul-17	Artificial neural Network	Aircraft Spare	Compared NN

Amirkolaii, A. Baboli, M. K. Shahzad, R. Tonadre			parts demand	with various forecasting techniques
K. H. van Donselaar, J. Peters, A. de Jong	May-08	Regression Analysis	Perishable items promotions	Routine and non-routine product categories
Kamala Aliyeva	2017	Regression Analysis with reliability	Manufacturing sector	z-regression model
Konstantinos I. Nikolopoulos, M. Zied Babai, Konstantinos Bozos	Jul-16	Exponential smoothing	Demand forecasting	Nearest neighbour theory
Koussaila Hamiche, Hassane Abouaïssa, Gilles Goncalves, TientéHsu	2018	Time series forecasting	Supply chain	Estimation using algebraic methods in time series
Liljana Ferbar Tratar, Blaž Mojškerc, Aleš Toman	Aug-16	Exponential Smoothing	Macroeconomic & Financial data	Development of four parameter Smoothing method
Lorenzo Tiaci, Stefano Satta	Mar-09	Exponential smoothing	Supplier replenishments	Evaluated effect of service level and total cost
M. Erdem Günay	2016	Artificial neural Network	Electricity demand	Use of socio economic indicators and climatic conditions
M. Hadi Amini, Amin Kargarian, Orkun Karabasoglu	Sep-16	Autoregressive integrated moving average (ARIMA)	Electric vehicle charging demand	Optimization of order parameters
Maria Rosienkiewicz, Edward Chlebus, Jerzy Detyna	Sep-17	Artificial neural Network	Spare parts lumpy demand	Use of Bayesian information criteria
Michele Romano, Zoran Kapelan	Jun-14	Artificial neural Network	short term Water Demand Forecasting	Adaptive algorithms
Muhammad Qamar Razaa, Abbas Khosravi	Oct-15	Artificial neural Network, Fuzzy	Load Demand Forecasting	Compared various forecasting techniques
Nicolas Perez-Mora, Victor Martinez-Moll, Vincent Canals	Jun-16	Artificial neural Network	District Heating and Cooling Energy Management	Multiple input parameters
Nooriya A. Mohammed	Nov-18	Artificial neural Network	Electricity demand	Heuristic modelling
Özlem Cosgun, Yeliz Ekinci, Seda Yanık	May-14	Fuzzy logic	Maritime Demand forecasting	dynamic pricing model
Qunli Wu, Chenyang Peng	Feb-17	Simulated Annealing Energy Demand	Energy Demand	Gaussian perturbation

		Estimation		
Rafael S. Gutierrez, Adriano O. Solisb., Somnath Mukhopadhyay	2008	Artificial neural Network	Lumpy demand	Compared with conventional techniques
S. Shabani, Gh. Naser	2015	Time series forecasting	Water Demand Forecasting	Quantified Chaos in time series
S. K. Sharma, G. K. Sharma,	2015	Time series and Regression Analysis	Domestic demand forecast of Lead Metal	Compared various forecasting techniques
Saima Hassan, Abbas Khosravi, Jafreezal Jaafar	Nov-16	Extreme learning machine	Electricity load forecasting	Combined neuro fuzzy model
Sandberg et al	Nov-16	Artificial neural Network	District heat demand	Multiple input parameters
Song Li, Lalit Goel, Peng Wang	Dec-16	Artificial neural Network	short term Load Forecasting	Extreme learning machine
Tingting Fang, Risto Lahdelma,	Oct-16	Regression Analysis	Heat demand forecasting; Least squares	Compared with SARIMA models
Tobias Pohlmann, Bernhard Friedrich	Jun-13	Trend Analysis	Point-of-sale data; Order history	Information minimization model
Tsung-Hsien Tsai, Chi-Kang Lee, Chien-Hung Wei	2009	Artificial neural Network	Railway passenger demand	Proposed multiple temporal units neural network
Tugba Efendigil, Semih Önüt, Cengiz Kahraman	2009	Artificial neural Network	supply chain demand	Compared with neuro fuzzy model
Xiao-Chen Yuan, Yi-Ming Wei	2017	Bayesian Approach	Energy Demand	Long term forecast with probabilistic approach
Yi Xiao, John J. Liu	2014	Neuro-fuzzy combination model	Air transport demand	Irregular, highly volatile and seasonal demand
Zafer Dilaver, Lester CHunt	Sep-16	Trend Analysis	Electricity demand	Estimation equation
Zheng Li John M. Rose David A. Hensher	Jan-10	Autoregressive integrated moving average (ARIMA)	petrol demand	Compared with other conventional techniques

COMPARISON OF DEMAND FORECASTING TECHNIQUES

Based upon the literature, each demand forecasting technique was evaluated on various fronts. Considering the different natures of two types, Conventional techniques and non-conventional techniques were separately compared amongst themselves. Comparison started with finding out the main focus area for each of the demand forecasting techniques. Other basic differences in techniques were evaluated considering the conditions in which they are more accurate, the time horizon of forecasts, nature of analytical process, cost, the effect of seasonality etc. Table-2 and table 3 have been presented below comparing the techniques on the basis of different features.

Table 2: Comparison of Various Conventional Demand Forecasting Techniques

S. No	Technique Feature	Survey Methods			Statistical Methods			
		Collective Opinion Method	Delphi Method	Consumer's Interview Method	Trend Projection Method	Correlation-Regression Method	Barometric Technique	ARIMA/SARIMA
1	Main focus	Salesman estimates	Expert's views	Consumer's Response	Previous Year Data	Relationship b/w Demand and other variables	Economic Indicators	Previous data
2	Beneficial for	New Products	Non-economic Variables	First-hand information from Consumer	Previous data available	Measuring effect of other variables	Improving Trend method using indicators	better understanding of data
3	Analysis process	Simple	Simple	Simple	Mathematical Analysis	Complex Statistical analysis	Simple	Complex
4	Nature of Forecast	Subjective	Subjective	Subjective	Quantitative	Quantitative	Quantitative	Quantitative
5	Forecast Period	Long term	Long term	Short/ Long term	Short term	Short term	Long term	Short term
6	Consideration of seasonality?	Yes	Yes	Yes	Yes (Decomposition Method, Holt Winter's Method)	No	No	Yes (SARIMA)
7	Cost	Low	Low	High	Low	Low	Low	Low
8	Consideration of Factors which may affect demand in future?	No	No	No	No	Yes	Yes	No

Table 3: Comparison of Various Non- Conventional Demand Forecasting Techniques

Sr. No.	Technique Feature	Artificial Neural Network	Fuzzy Logic	Bayesian Approach	Wavelet Transform	Genetic Algorithm	Particle Swarm Optimization
1	Good choice for use when	1. Unknown Non-linear relation between input and outputs, 2. training data available	1. Vague non-linear relation, 2. can be used even with incomplete data,	Probabilistic forecasting Model	Improving the performance of Time series analysis	1. Optimum solution is required, 2. Relation between factors Understood well enough	Mainly Optimization technique
2	Benefits	Identify complex relations	Computing with words	Mathematical modelling results tell exact relation between input and output	Model both the trend and the seasonality, Stochastic Errors	Optimized results	simple Computation
3	Analysis process	Training, testing	If-then rules	Baye's Theorem, probability distribution	Decompose a time series into a linear combination of different components	Mutation, crossover	Speed of the particle
4	Nature of Forecast	Quantitative	Quantitative	Quantitative	Quantitative	Quantitative	
5	Forecast	short/medium	short/medium	short/ long	short/ long		

	Period						
6	Consideration of seasonality?	Yes	Yes	No	yes	Yes	No
7	Consideration of Factors which may affect demand in future?	Yes	Yes	Yes	No	Yes	Yes
8	Main Limitation	1. Inputs must be in data format 2. Act like a black box	1. Determining exact fuzzy rules and relationships is hard. 2. Generally used with ANN as ANFIS	Result in Complex Probabilistic model if inputs are more	1. Increased Model complexity 2. Selection of Appropriate Wavelet Transform	1. Slow learning process 2. Must be combined with other method for better forecasts	Must be combined with other method for forecasting e. g. Fuzzy logic

CONCLUSIONS

In this paper, an attempt has been made to review the literature on demand forecasting techniques which have been published in last 10 years. With the help of reviews, comparison has been made between the various demand forecasting techniques on various fronts. It is evident from the study that the modern world problems have become much more complicated and complex to be solved by simple conventional techniques. Ever evolving new technology is continuously being employed for improving the accuracy of forecasts. We hope that this study will contribute to a better understanding of various forecasting techniques and help in solving more and more complex problems.

REFERENCES

1. Abderreza kLaouafi, Mourad Mordjaoui, Salim Haddad, Taqiy Eddine Boukelia, Abderahmane Ganouche, *Online electricity demand forecasting based on an effective forecast combination methodology*, *Electric Power Systems Research*, Volume 148, July 2017, Pages 35-47, ISSN 0378-7796,
2. Alexander Sandberg, Fredrik Wallina, Hailong Lia, Maher Razaa, *An Analyze of Long-term Hourly District Heat Demand Forecasting of a Commercial Building Using Neural Networks*, *Energy Procedia* 105 (2017), pp.3784 – 3790
3. Arash Kialashaki, John R. Reisel, *Development and validation of artificial neural network models of the energy demand in the industrial sector of the United States*, *Energy* Volume 76, 1 November 2014, Pages 749-760
4. "Bruno M. Brentan, Edevar Luvizotto Jr. et al, *Hybrid regression model for near real-time urban water demand forecasting*, *Journal of Computational and Applied Mathematics* Volume 309, 1 January 2017, Pages 532-541
5. Edward Kozłowski, Beata Kowalska, Dariusz Kowalski, Dariusz Mazurkiewicz, *Water demand forecasting by trend and harmonic analysis*, *Archives of Civil and Mechanical Engineering* Volume 18, Issue 1, January 2018, Pages 140-148
6. Ergun Yukseltan, Ahmet Yucekaya, Ayse Humeysra Bilge, *Forecasting electricity demand for Turkey: Modelling periodic variations and demand segregation*, *Applied Energy*, Volume 193, 1 May 2017, Pages 287-296, ISSN 0306-2619
7. F. Lolli, R. Gamberinia et al, *Single-hidden layer neural networks for forecasting intermittent demand*, *Int. J. Production Economics* 183 (2017) 116–128
8. Federico Poloni, Giacomo Sbrana, *A note on forecasting demand using the multivariate exponential smoothing framework*, *International Journal of Pr. Economics* Volume 162, April 2015, Pages 143-150
9. Masih, J., & Nim, D. *Trend Forecasting Of Twitter Followers For Plan International*.

10. Feng Guo, Jun Diao, QiuHong Zhao, Dexin Wang, Qiang Sun, A double-level combination approach for demand forecasting of repairable airplane spare parts based on turnover data, *Computers & Industrial Engineering*, Available online 3 May 2017, ISSN 0360-8352.
11. Humberto Verdejo, Almendra Awerkin, Cristhian Becker, Gabriel Olguin, Statistic linear parametric techniques for residential electric energy demand forecasting. A review and an implementation to Chile, *Renewable and Sustainable Energy Reviews*, Volume 74, July 2017, Pages 512-521, ISSN 1364-0321.
12. Hyojoo Son, Changwan Kim, Short-term forecasting of electricity demand for the residential sector using weather and social variables, *Resources, Conservation and Recycling* Volume 123, August 2017, Pages 200-207
13. Ioannis P. Panapakidis, Athanasios S. Dagoumas, Day-ahead natural gas demand forecasting based on the combination of wavelet transform and ANFIS/genetic algorithm/neural network model, *Energy* Volume 118, 1 January 2017, Pages 231-245
14. BIRÁU, F. R. (2014). Forecasting financial time series based on Artificial Neural Networks. *IMPACT: International Journal of Research in Business Management (IMPACT: IJRBM)*, ISSN (E).
15. Jakob Huber, Alexander Gossmann, Heiner Stuckenschmidt, Cluster-based hierarchical demand forecasting for perishable goods, *Expert Systems with Applications*, Volume 76, 15 June 2017, Pages 140-151, ISSN 0957-4174
16. JenniEer J. Bergman, James S. Noble, Ronald G. McGarvey, Randolph L. Bradley, A Bayesian approach to demand forecasting for new equipment programs, *Robotics and Computer-Integrated Manufacturing*, Volume 47, October 2017, Pages 17-21, ISSN 0736-5845.
17. Jongsu Lee, Youngsang Cho, Demand forecasting of diesel passenger car considering consumer preference and government regulation in South Korea, *Transportation Research Part A: Policy and Practice* Volume 43, Issue 4, May 2009, Pages 420-429
18. José Roberto do Rego, Marco Aurélio de Mesquita, Demand forecasting and inventory control: A simulation study on automotive spare parts, *International Journal of Production Economics* Volume 161, March 2015, Pages 1-16
19. Julia García Cabello, F. J. Lobillo, Sound branch cash management for less: A low-cost forecasting algorithm under uncertain demand, *Omega*, Volume 70, July 2017, Pages 118-134, ISSN 0305-0483,
20. K. Nemati Amirkolaii, A. Baboli, M. K. Shahzad, R. Tonadre, Demand Forecasting for Irregular Demands in Business Aircraft Spare Parts Supply Chains by using Artificial Intelligence (AI), *IFAC-PapersOn-Line* Volume 50, Issue 1, July 2017, Pages 15221-15226.
21. K. H. Van Donselaar, J. Peters, A. deJong, R. A. C. M. Broekmeulen, Analysis and forecasting of demand during promotions for perishable items, *International Journal of Production Economics* Volume 172, February 2016, Pages 65-75
22. Kamala Aliyeva, Demand forecasting for manufacturing under Z-Information, *Procedia Computer Science* Volume 120, 2017, Pages 509-514
23. Konstantinos I. Nikolopoulos, M. ZiedBabai, Konstantinos Bozos, Forecasting supply chain sporadic demand with nearest neighbour approaches, *International Journal of Production Economics* Volume 177, July 2016, Pages 139-148
24. Koussaila Hamiche, Hassane Abouaïssa, Gilles Goncalves, Tienté Hsu, A Robust and Easy Approach for Demand Forecasting in Supply Chains, *IFAC-PapersOn-Line* Volume 51, Issue 11, 2018, Pages 1732-1737
25. Liljana Ferbar Tratar, Blaž Mojškerc, Aleš Toman, Demand forecasting with four-parameter exponential smoothing, *International Journal of Production Economics*, Volume 181, Part A, November 2016, Pages 162-173

26. "Lorenzo Tiacchi, Stefano Saetta, An approach to evaluate the impact of interaction between demand forecasting method and stock control policy on the inventory system performances, *International Journal of Production Economics* Volume 118, Issue 1, March 2009, Pages 63-71
27. "M. Erdem Günay, Forecasting annual gross electricity demand by artificial neural networks using predicted values of socio-economic indicators and climatic conditions: Case of Turkey, *Energy Policy* 90 (2016) 92–101
28. M. HadiAmini, Amin Kargarian, Orkun Karabasoglu, ARIMA-based decoupled time series forecasting of electric vehicle charging demand for stochastic power system operation, *Electric Power Systems Research* Volume 140, November 2016, Pages 378-390
29. Maria Rosienkiewicz, Edward Chlebus, Jerzy Detyna, A hybrid spares demand forecasting method dedicated to mining industry, *Applied Mathematical Modelling*, Volume 49, September 2017, Pages 87-107, ISSN 0307-904X
30. Michele Romano, Zoran Kapelan, Adaptive water demand forecasting for near real-time management of smart water distribution systems, *Environmental Modelling & Software* 60 (2014) 265-276
31. Thupeng, W. M., Mothupi, T., Mokgweetsi, B., Mashabe, B., & Sediadie, T. (2018). A Principal Component Regression Model, for Forecasting Daily Peak Ambient Ground Level Ozone Concentrations, in the Presence of Multicollinearity Amongst Precursor Air Pollutants and Local Meteorological Conditions: A Case Study of Maun.
32. Nikolaos Kourentzes, Bahman Rostami-Tabar, Devon K. Barrow, Demand forecasting by temporal aggregation: Using optimal or multiple aggregation levels?, *Journal of Business Research*, Volume 78, September 2017, Pages 1-9, ISSN 0148-2963
33. "Nooriya A. Mohammed, Modelling of unsuppressed electrical demand forecasting in Iraq for long term, *Energy* Volume 162, 1 November 2018, Pages 354-363
34. ÖzlemCosgun, YelizEkinci, SedaYanık, Fuzzy rule-based demand forecasting for dynamic pricing of a maritime company, *Knowledge-Based Systems* 70 (2014) 88–96
35. "Qunli Wu, ChenyangPeng, A hybrid BAG-SA optimal approach to estimate energy demand of China, *Energy* Volume 120, 1 February 2017, Pages 985-995"
36. Rafael S. Gutierrez, Adriano O. Solis, , Somnath Mukhopadhyay, Lumpy demand forecasting using neural networks, *Int. J. Production Economics* 111 (2008) 409–42
37. S. Shabani, Gh. Naser, Dynamic nature of explanatory variables in water demand forecasting, *Procedia Engineering* Volume 119, 2015, Pages 781-787
38. S. K. Sharma, G. K. Sharma, Demand forecasting Technique vis-à-vis demand forecast for lead, *Procedia Earth and Planetary Science* 11 (2015) 418 – 424
39. "Saima Hassan, Abbas Khosravi, JafreezalJaafar, Mojtaba Ahmadi Khanezar, A systematic design of interval type-2 fuzzy logic system using extreme learning machine for electricity load demand forecasting, *International Journal of Electrical Power & Energy Systems* Volume 82, November 2016, Pages 1-10
40. Sha Zhu, Rommert Dekker, Willem van Jaarsveld, Rex Wang Renjie, Alex J. Koning, An improved method for forecasting spare parts demand using extreme value theory, *European Journal of Operational Research*, Volume 261, Issue 1, 16 August 2017, Pages 169-181, ISSN 0377-2217
41. "Song Li, LalitGoel, Peng Wang, An ensemble approach for short-term load forecasting by extreme learning machine, *Applied Energy* Volume 170, 15 May 2016, Pages 22-29

42. "Tingting Fang, Risto Lahdelma, Evaluation of a multiple linear regression model and SARIMA model in forecasting heat demand for district heating system, *Applied Energy* Volume 179, 1 October 2016, Pages 544-552
43. Tobias Pohlmann, Bernhard Friedrich, A combined method to forecast and estimate traffic demand in urban networks, *Transportation Research Part C: Emerging Technologies* Volume 31, June 2013, Pages 131-144
44. Tsung-Hsien Tsai, Chi-Kang Lee, Chien-Hung Wei, Neural network based temporal feature models for short-term railway passenger demand forecasting, *Expert Systems with Applications* 36 (2009) 3728–3736
45. Tugba Efendigil, Semih Önüt, Cengiz Kahraman, A decision support system for demand forecasting with artificial neural networks and neuro-fuzzy models: A comparative analysis, *Expert Systems with Applications* 36 (2009) 6697–6707
46. Xiao-Chen Yuan, Yi-Ming Wei, ZhifuMi, Xun Sun, Weigang Zhao, Bing Wang, Forecasting China's regional energy demand by 2030: A Bayesian approach, *Resources, Conservation & Recycling* 127 (2017) 85–95
47. Yi Xiao, John J. Liu, Yi Hu, Yingfeng Wang, Kin Keung Lai, Shouyang Wang, A neuro-fuzzy combination model based on singular spectrum analysis for air transport demand forecasting, *Journal of Air Transport Management* 39 (2014) 1-11
48. ZaferDilaver, Lester CHunt, Modelling and forecasting Turkish residential electricity demand, *Energy Policy* Volume 39, Issue 6, June 2011, Pages 3117-3127
49. Zheng Li John M. Rose David A. Hensher, Forecasting automobile petrol demand in Australia: An evaluation of empirical models, *Transportation Research Part A: Policy and Practice* Volume 44, Issue 1, January 2010, Pages 16-38